Isothermal Dendritic Growth Experiment (IDGE) Is the First United States Microgravity Experiment Controlled From the Principal Investigator's University

Members of the Lewis-based IDGE team assemble the flight unit. One of the IDGE 35-mm cameras and the Space Acceleration Measurement System (SAMS) sensor head are visible. IDGE is fully operable by remote control from Earth--a feature that contributed to its remarkable success on STS-62 and STS-75.

The scientific objective of the Isothermal Dendritic Growth Experiment (IDGE) is to test fundamental assumptions about dendritic solidification of molten materials. "Dendrites"--from the ancient Greek word for tree--are tiny branching structures that form inside molten metal alloys when they solidify during manufacturing. The size, shape, and orientation of the dendrites have a major effect on the strength, ductility (ability to be molded or shaped), and usefulness of an alloy. Nearly all cast-metal alloys used in everyday products, such as automobiles and airplanes, are composed of thousands to millions of tiny dendrites.

Gravity, present on Earth, causes convection currents in molten alloys that disturb dendritic solidification and make its precise study impossible. In space, the effects of gravity are negated by the orbit of the space shuttle. Consequently, IDGE enabled the acquisition of the first precise data regarding undisturbed dendritic solidification.

IDGE is a microgravity materials science experiment using apparatus that was designed, built, tested, and operated by people from the NASA Lewis Research Center. The IDGE experiment was conceived by the principal investigator, Professor Martin E. Glicksman from Rensselaer Polytechnic Institute in Troy, New York. This experiment was a team effort of civil servants from the NASA Lewis Research Center, contractors from Aerospace Design & Fabrication, Inc. (ADF), and personnel at Rensselaer.

In February 1996, IDGE was launched for the second time aboard the Space Shuttle Columbia on the STS-75 mission, as part of the Third United States Microgravity Payload (USMP-3) series. This highly successful experiment became the first U.S. microgravity experiment to be commanded and controlled from an investigatorís own control center at a university. The commanding of an experiment at an investigatorís site is referred to as telescience. With the dawn of the Space Station Era, where experiments will be performed over a period of months rather than weeks, this is an important capability, since it is not feasible for investigators to spend that much time at NASA operations centers. In addition, telescience opens up new educational opportunities for students at universities to become intimately involved in the space program.

The flight objective was to acquire the large amounts of data required to make definitive determinations of the three-dimensional shape of dendrite tips. Data are currently being analyzed at Rensselaer. In addition, data were acquired that revealed that the residual microgravity environment of space does not affect the direction and orientation of dendritic growth, as was previously theorized.

More than 120 dendrites were grown over the 15 days of operation--more than double the data returned from the first flight. These dendrites were solidified at over 20 different supercoolings, ranging from about 0.1 to 1.2 K. (Supercooling is the term used to describe the condition in which a dendrite solidifies at a temperature below its normal freezing point.) The data consisted of over 400 photographs and over 800 television images of dendrites solidifying in space, along with associated supercooling, pressure, and acceleration data. Photographs were possible because the test material was transparent succinonitrile, which mimics the behavior of iron when it solidifies.

Dendrite tip radii, tip solidification speed, and volumetric solidification rates have been determined from data gathered in space and on Earth. These were compared with predictions made by theorists over the last 50 years, which are currently used for metal production here on Earth. IDGE results indicate that these theories, although sound in some respects, are flawed in others. Consequently, corrected theories based on IDGE data should result in improved industrial metal production.

IDGE is scheduled to fly for the third time aboard the Space Shuttle Columbia on the STS-87 mission in October 1997. The IDGE apparatus will be modified to grow dendrites from a new sample material. This will allow a definitive test of the universality of both current and future dendritic solidification theories.

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